Summary of Contaminated Sediment Capping Projects

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Built	Performance	Comments	References
Puget Sound/Washington										
1	Duwamish Waterway Seattle, Washington (CAD)	Heavy metals, PCBs	Existing 6-ft. deep subaqueous depression; Waterway depth 70 ft.	3 ft. design target; 2 ft. actual average after consolidation (21)	Sand (4,000 cy)	1.3 acres estimated [(a)] 0.7 acre original cap size (21)	1984	• Functionally no erosion (a small amount of cap eroded from one side to another, but was then covered by natural sedimentation) (21) • No chemical migration observed in second and third coring operations (21) • Concentrations of heavy metals and PCBs were at least an order of magnitude lower in the sand cap than in contaminated material below (22) • The 18-month and 5-yr sediment chemistry sand-cap concentrations matched almost exactly (22) • Interface between contaminated and cap sediments was sharp and relatively unmixed (22)	• First capping project (a "learning experience") in EPA Region 10 • Led by the USACE with limited involvement from EPA (21) • Key lessons learned: relationship between contaminated sediment fill volumes, CAD cell size, and rate of CAD filling (21) • Split-hull dump barge placed sand over relocated sediments in CAD cell (A) • Maximum sustained bottom currents: 0.2 ft/sec (occasional readings in the upper water column approaching 1.0 ft/sec) (23)	A, E, F, 21, 22, 23
2	One Tree Island Olympia, Washington (CAD)	Heavy metals, PAHs	Marina; 14.8 ft. deep	4 ft. (in order to obtain a consolidated cap of 3 ft.) (21)	Sand Clean sediment (E)	0.5 acres	1987	• Applied lesson from Duwamish: allow contaminated material to consolidate on barge and then to settle in CAD cell (1 - 2 weeks) (21) • Little prop scour; recreational divers said that cap appeared to be intact (21) • No chemical migration (A) • No erosion of cap (A)	• First permitted CAD project (21) • Maintenance dredging of a marina; top 2-3 ft. of contaminated sediments were dredged and placed in "overbuilt" (or "very deep") CAD cell in marina (21) • No ongoing monitoring required (21) • Last monitoring occurred in 1989 and showed that sediment contaminants were contained (A)	A, C, E, 21

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Built	Performance	Comments	References
3	St. Paul Waterway (Simpson Tacoma Kraft Superfund Site) Tacoma, Washington (ISC and habitat restoration)	Phenols, PAHs, dioxins, furans	Shallow, near shore sediments, 11.5 ft. deep Depth now is -20 ft. MLLW at extreme (21)	2-12 ft. 4.9-19.7 ft. actual (B, E) 3.9 ft. design (E) 3 - 13 or 14 ft. (36)	Coarse sand from Puyallup River	17 acres (11 acres of marine sediments capped; 6 acres of new intertidal habitat built along shoreline) (32)	1988	• Intensive monitoring conducted annually for 10 years (36) • Monitoring recently scaled back; cap will be checked every other year to ensure that it is still in place and that the elevation has not changed substantially; cap will be checked after any major storm or earthquake (36) • Everything is working fine; no chemical migration; cap still within specifications (A,21,36) • PRP won environmental award for habitat creation (21) • > 10 years of chemical and biological monitoring show contaminated sediments have remained confined and isolated beneath cap and cap is providing good habitat for estuarine biota (32) • St. Paul Waterway was delisted from the NPL on 10/29/96 (32)	• First designed and permitted capping project under Superfund regulatory process (21) • Some redistribution of cap materials occurred, but overall design level met (36) • C.californieus (typical deep burrowers that can cause bioturbation) found in sediments, but never at depths >1 m (3.3 ft.) (A); bioturbation would have been limited (21)	A, B, C, E, 21, 32, 36
4	Pier 51 Ferry Terminal Elliott Bay Seattle, Washington (ISC)	Mercury, heavy metals, PAHs, PCBs, PCDF	Docks at 20-25 ft. 60 to 100 ft. (at approx. 150 ft. from shore)	Docks: 4 ft. design (to achieve 3 ft. consoli-dation) (at water depths of approx. 35 ft. Rest of Site: 1.5 - 2 ft. design (to achieve 1 ft. consolidated)	Coarse sand	4 acres (2 acres with thick cap; 2 acres with thinner cap)	1989	• No chemical migration (A) • Cap within specifications (A) • Recolonization observed (A) • As recent as 1994, cap thickness remained within design specifications (A) • While benthic infauna have recolonized the cap, there is no indication of cap breach due to bioturbation (A) • For 1 or 2 years, the thinner cap was not as clean as the original cap, possibly due to mixing; the thicker cap remained clean (21) • No ongoing monitoring required (21) • Caps worked very well (21)	• Project was primarily an experiment to see if ferries would blow the cap away (hence thicker cap employed at the ferry area) (21) • During reconstruction of ferry terminal, a piling was pulled up, recontaminating the cap with creosote - cap was repaired (21) • Cap was recontaminated in top ~2cm with metals; fate and transport study demonstrated that ferry terminal was at nexus of two gyres (from north and south); this knowledge partially dictated subsequent cleanup efforts (21)	A, E, 21

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Built	Performance	Comments	References
5	Denny Way CSO Elliott Bay Seattle, Washington (ISC)	Heavy metals, PAHs, PCBs	Water depth 18-50 ft.	2-3 ft.	Sand Sandy sediment from Duwamish Waterway	3 acres	1990	• 1994 cores showed recontamination in cap surface, but no migration of chemicals through cap (A) • Recontamination likely from CSO (21)	• CSO once discharged primary sewage; now discharges storm water and wastewater from some wastewater treatment plants (21) • An original project goal was to study rate of recontamination at cap surface using a mass balance approach; found not to be possible (21)	A, B, C, E, 21
6	Piers 53-55 CSO Seattle, Washington (ISC)	Heavy metals, PAHs, PCBs	Similar to those at Pier 51 (21)	1.3-2.6 ft. (A) Similar to those at Pier 51 (21)	Sand Material from Duwamish Waterway (E)	4.5 acres	1992	• No chemical migration • Cap stable, and increased by 15 cm (6 in.) of new deposition • Gyre caused sediments to erode from cap, but remaining cap seemed stable (although materials were spread around a lot) (21) • Accretion zone (21) • Difficult to discern volumes from consolidation vs. erosion (21) • Infaunal communities returned changed; much more shading after cap placement (21)	• Material sprayed under existing piers to form cap (21) • Pre-cap infaunal communities were destroyed in the rapid burial associated with cap construction (A) • Constituents from adjacent sediment site have been deposited in cap surface (E) • The amount of sediment accumulation was not anticipated; the ferry terminal creates a quiescent area, causing sediment dropout (21)	A, E, 21
7	Pier 64 Seattle, Washington (ISC)	Heavy metals, PAHs, phthalates, dibenzofuran	Water depth 20-59 ft.	0.5-1.5 ft.	Sand	32.1 acres (E) 4 acres (NN)	1994	• Some loss of cap thickness in western portion; reasons unclear (erosion or consolidation/settling) • Reduction in surface chemical concentrations noted • Post capping water column monitoring showed concentrations of metals and organics to be below pre-capping concentrations (NN)	• Thin-layer capping used to enhance natural recovery and reduce resuspension of contaminants during pile driving (A) • A pier expansion project; old creosote-covered wood pilings replaced with concrete pilings, which are further spaced, allowing more light and more habitat (although still have issues with shading) (21) • Capping placed under and in front of pilings (21)	A, E, NN, 21

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Built	Performance	Comments	References
8	GP Log Pond Whatcom Waterway Bellingham, Washington (ISC and beneficial habitat creation)	Mercury, phenols	Conversion of deep subtidal, shallow subtidal mudflat/debris and low intertidal riprap ; -5 ft MLLW (31)	Phase 1: 0.5 to 3 ft. Phase 2: 0 - 6 ft. Total: 0.5-10 ft. (31)	Phase 1: Coarser sand dredged material Phase 2: Finer-grained navigational dredge material (31)	5.6 acres (31)	Nov. 2000 to Feb. 2001 (31)	• No chemical migration at 3 months (A) • Cap successfully placed (A, 31)	• Interim Remedial Action under authority of State Model Toxics Control Act • Cap surface constructed using substrates and elevations to create beneficial use habitat • Full sediment removal was not practical because: (1) dredging with high amounts of debris would cause significant impacts to the water column, (2) dredging could have compromised integrity of containment structures (nearshore fill) for other hazardous substances, and (3) existing docks, dolphins, and shoreline structure present within or adjacent to the Log Pond would likely have been adversely impacted by a full removal action (31)	A, M, 21, 31

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Built	Performance	Comments	References
9	East Eagle Harbor/Wyckoff Bainbridge Island, Washington (ISC and intertidal habitat creation)	PAHs (36)	Phase I: contaminated subtidal harbor sediments capped Phase II: contaminated nearshore sediments capped Water depths 0-45 ft. (36)	Phase I: 3 ft. (36) Phase II: 3 ft. (36)	Phase I: Clean river sediment (275,000 cy) Phase II: Upland fill (clean sand) (120,000 cy) (28) Phase III: upland fill (80,000 cy) (36)	Phase I: 54.4 acres (E) Phase II: 15 acres (36) Phase III cap on Phase II area (slightly smaller footprint) (36)	Phase I: 1993-1994 Phase II: 2000-2001 Phase III: 2001-2002	• No chemical migration • Cap erosion measured within first year of monitoring in area near heavily used Washington ferry dock • After Phase I cap placement, pools of creosote were observed at cap edges; pools likely migrated from Phase II/III area, which was not contained at the time; divers extracted the pools regularly (36) • Ongoing monitoring planned for another 10 years; then, more monitoring likely (36) • Ongoing releases from ferry parking lot and other upland sources (36) • Cap is working very well; monitoring shows that cap is staying in place and is preventing chemical migration; the agency is very happy with the cap (36) • NOAA study documented rapid and substantial increase in quality of habitat (36)	• Phase I objective: reduce immediate risk (28) • Additional remediation delayed until upland source control achieved (the fall 2000 installation of sheet pile wall) (28) • Phase II objective: extend cap from 1994 cap's approx. 2-ft. thickness contour (about 900 ft. offshore) to northern shoreline of Wyckoff facility (and to coordinate with construction of new intertidal habitat area on western portion of site) (28) • Phase III objective: place 80,000 cy clean sediment to build an intertidal area connecting Phase II area to north shoal (28) and to add more confinement material to the cap (36) • Just finished placing the Phase III material in mid-February 2002 (36) • There is now a huge area that provides intertidal habitat for endangered species (36)	A, B, D, E, 28, 36
10	West Eagle Harbor/Wyckoff Bainbridge Island, Washington (ISC)	Mercury, PAHs	Water depth 0-45 ft.	Thin cap (0.5 ft.) over 6 acres Thick cap (3 ft.) over 0.6 acres	Quarry sand (22,600 tons for thin cap and 7,400 tons for thick cap)	6.6 acres	Partial dredge and cap 1997	• No chemical migration • Post-implementation surveys identified 16 discrete cap areas lacking in minimum thickness, so another 1,000 cy added (NN) (EPA will check this statement)	• To date, post-verification surface sediment samples have met the cleanup criteria established for the project • Ongoing monitoring • Cap has achieved its intended function and is doing well (36)	A, NN, 36

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Built	Performance	Comments	References
11	Middle Waterway Commencement Bay Nearshore/Tideflats Superfund Site (CB/NT SS) Tacoma, Washington	Mercury, PAHs, PCBs (21)	Original shoreline and mudflats; completely intertidal; high tide depths: about 13-15 ft. where capped (21)	2-3 ft. (related to habitat design) (21)	To be determined (48)	3.95 acres of thin layer cap and 0.24 acres with 3 ft. cap (per draft 8/01 document) (30)	Scheduled for early 2003		• April 1997 Consent Order • The project just entered the "Remedial Design Phase", a significant portion of which will involve capping (21) • A few portions will be dredged because of navigation requirements (21) • Remedy includes dredging with near-shore-confined disposal, monitored natural recovery, thin-layer capping and thick capping (30)	GG, 21, 30, 48
12	Thea Foss Waterway CB/NT SS Tacoma, Washington	PAHs, phthalate esters, trace metals, PCBs (46), dioxins (21)	8000-ft. waterway; depth is about 15 ft. now; depth in main channel may be restored to 20-25 ft.	3 ft. for thick caps (50) possibly 0.5 to 1 ft. for thin caps	To be determined	Approx. 20 acres (46, 50)	To be constructed (EPA's selected remedy)	• The in-situ cap will be thick enough to contain and isolate contaminated sediments in situ from the overlying water column and habitat, and will be thick enough to resist erosion from vessel scour, wave action, or penetration by burrowing organisms (46) • 100% design expected to be complete in March 2002 (50)	• 1994 EPA Consent Decree with City of Tacoma • Project focus is not on habitat, although benefits to endangered species habitat will be considered (21); 14 acres of intertidal habitat are proposed (46) • A portion of each of the project's 8 sediment management areas (SMAs) will be thick-capped; the SMA at the head of the waterway will also employ sorbent capping to control oil seepage (46) • Enhanced natural recovery to be used at mouth of waterway (50) • Majority of sediments in navigation channel will be dredged (50)	21, 46, 50

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Built	Performance	Comments	References
13	Olympic View Resource Area CB/NT SS Tacoma, Washington	Dioxin	Intertidal area with a small subtidal area; water depth is -15 ft. MLLW	4 ft.	Erosion protection layer over 43 in. clean sand over geotextile barrier over 6 in. TOC material	1.0 to 1.6 acres	Construc-tion began in June 2002		• Approved non-time critical removal action (no ROD) • Highest dioxin concentrations in area • Site covers 12 acres, but 2.2 acres (review with EPA) will be remediated • Approximately 51,000 sq.ft. will be excavated down 1.1 ft and backfilled with clean material. The other portion (1.0 acres or 68,290 sq. ft.) will be capped (review with EPA)	10
14	General Metals of Tacoma Hylebos Waterway CB/NT SS Tacoma, Washington (ISC)	Metals, PAHs		3 ft.	Sand, gravel, geotextile liner	800 feet along shoreline under piers	Late 1990s	• Recent monitoring indicates that cap is functioning as designed	• Capping conducted in conjunction with repair work on dock/bulkhead structure by General Metals • Capping selected because dredging presented concerns about undermining dock structural integrity	49
15	Occidental Chemical Removal Action Hylebos Waterway CB/NT SS Tacoma, Washington (trial cap)								• Message left with EPA Region 10	49
16	Asarco Sediments/ Groundwater Operable Unit 06 CB/NT SS Tacoma, Washington (pilot)	Arsenic, lead, copper	Near old smelter site	30 cm and 60 cm (side by side)	Clean river sediments			• Pilot cap was very successful	• Pilot study was conducted to determine if cap would remain in place and become recolonized with healthy biological communities	51

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Built	Performance	Comments	References
17	Asarco Sediments/Ground water Operable Unit 06 CB/NT SS Tacoma, Washington (full-scale)	Arsenic, lead, copper	Near old smelter site; cap will be 0 - 60 ft. deep	3 ft.	To be determined	18 acres	To be constructed (ROD signed in July 2000)		• Entire yacht basin will be dredged (about 20 acres) • Offshore contaminated sediments will be capped • Draft 30% design completed • Cap will integrate into armored shoreline (2/3 of armor has been placed) • Entire peninsula created by pouring arsenic-containing slag into the water, (slag is 100 feet thick in places); dredge volumes would have been too great so it was determined to isolate contaminants from benthic organisms by using a 3-foot-thick cap	51
18	Lockheed Shipyard Duwamish River/Elliott Bay Seattle, Washington	Primarily arsenic, lead, mercury, zinc, copper; some PCBs and PAHs	Navigable river; major salmon route; water depth ~ 20 ft.	2 ft. minimum (ROD) 3.5 ft. currently under consideration	To be determined	Approx. 15 acre (based on 3.5 ft. cap and 85,210 cy of cap material)	Possible pier removal this winter; dredging and capping may begin in the fall or winter of 2003		• A huge pier will be removed; that area will be dredged and then capped to prevent contaminant migration and to improve aquatic habitat • Area beyond current pier will be dredged but not capped • Design has not been finalized • Capping is part of remedy per ROD	58
19	Todd Shipyard Duwamish River/Elliott Bay Seattle, Washington	Primarily arsenic, lead, mercury, zinc, copper, TBT; some PCBs, PAHs	Navigable river; major salmon route; very steep slopes (drops from 30 to 50 depths rapidly)	To be determined	To be determined	To be determined	Dredging and capping may begin in the fall or winter of 2003		• A more involved project than Lockheed; this is still a working shipyard and site has steep slopes • Design has not been finalized • Capping is part of remedy per ROD	58

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Built	Performance	Comments	References
20	Puget Sound Naval Shipyard Bremerton, Washington (CAD)	PCBs, mercury (48)	Depth varies; approx. 30 ft. at CAD (48)	Approx. 1 ft. (interim cap) and approx. 3 ft. (second cap), for total of 4 ft. before consolidation (48)	CAD cap: clean dredged material from turning basin (48)	CAD: approx. 10 acres (48)	Dredging completed in June 2000 Final CAD cap placed in Sept. or Oct. 2001 (48)	• Pit CAD sized properly (deep and wide) but experienced some "slop" (2-3 cm extending 20-50 ft. out) (21) • Key lesson learned: awareness of differences between "production" project and "environmental" project; apparently the project experienced bucket overfilling, overdredging, and underdredging, possibly causing problems with water quality (turbidity) (X) • The project went very well (48) • Monitoring plan is being developed now (48)	• Project involved dredging of channel and turning basin, and pier extension and reconstruction • Remedy included dredging, on-site disposal in CAD, thick and thin-layer capping, and natural recovery (29, 48) • Project unique because of significant volume of contaminated sediment (>390,000 cy), tight schedule, significant daily tidal exchange, water depth and CAD pit volume constraint (required precision dredging) (X)	X, 21, 29, 48
21	Pacific Sound Resources Seattle, Washington	PAHs, mercury, PCBs (33)	Old creosote plant located at mouth of Duwamish River; intertidal area to depths >240 ft. (33)	5 ft. in intertidal areas to -10 ft. MLLW (33) Other areas: to be determined (33)	Navigational dredged material or upland borrow intended (33)	Capping selected for 50-65 acres in remedial design (33)	ROD signed; pre-work (e.g., pilings removal, small dredge area) likely in 2003; capping possibly in 2003	• Approximately 20 acres of cap are on an 18-21% slope (33) • Cap likely designed to require repair after a significant earthquake (33)	• Remedy is mostly capping • In navigation channel, a depression to the lone dock (at area near former plant outfall) will be dug; those spoils will be consolidated onshore (21) • A beach will be built, with 5 ft. cap to tie into shoreline structure and habitat and to sequester contamination; thinner cap (6 inches) may be used away from shore (21)	21, 33
California, Oregon, and other Western States										

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Built	Performance	Comments	References
22	Port of Los Angeles Shallow Water Habitat (PSWH) Los Angeles, California (CAD and habitat creation) (the "Pier 400 project")	Heavy metals (esp. copper), PAHs, DDT, PCBs; a "historic soup"; large storm drain discharges to the area (38)	Bay not used for navigation; depth reduced from 40 ft. to 15 ft. to create habitat	15 ft.	13 ft. clean harbor material; 2 ft. clean sand (latter was habitat-driven)	94 acre CAD (FF) within 192-acre site	1995	• Project performance fine to date (27, 37, 38) • Recent discussions about possible expansion (27); expansion does include capping of any other contaminated sediments, but rather entails creation of 54 more acres of habitat (38) • No long term monitoring required (38) • 1993/94 monitoring showed that the cap was still in place (38)	• Overall effective cap was >15'. The thick cap was a result of site geometry and dredging volumes and was not required to prevent contaminant migration (FF, 38) • First CAD project in California for contaminated sediments (27) • A perimeter subaqueous berm was placed prior to placement of 5 million cy of contaminated sediments (27) • Provides habitat for endangered species (California lease tern) (27, 38) • Cap covered a designated "hot spot" (38)	A, FF, 27, 37, 38
23	Port of Los Angeles Shallow Water Habitat (PSWH) Los Angeles, California (pilot CAD)	Lead, zinc, copper		12 ft. (OO)	Sand cap over 44 geotextile containers filled with contaminated sediments	est. 10 acres[(b)]	Dredging from Nov. 10, 1994 to Dec. 18, 1994		• 66,000 cy contaminated maintenance dredged material from Marina del Rey and Ballona Flood Control channels were placed in geotubes	O, FF, OO, 27

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Built	Performance	Comments	References
24	Convair Lagoon San Diego Bay San Diego, California (ISC with foraging habitat creation)	PCBs	Water depth 10-18 ft. 10-acre site	2 ft. sand over 1 ft. rock	Sand over crushed rock and geogrid	5.7 acres	Oct. 1996 to mid-1998	• No chemical migration • Cap successfully placed in very shallow water • Some chemicals observed in cap • Could expect to see some chemicals in cap because of high energy environment (similar to Elliott Bay experiences) (27)	• State-ordered remediation of PCBs (27) • Ongoing monitoring for 20 to 50 years (includes diver inspection, cap coring, biological monitoring) • Designed to withstand a significant seismic event • 4 acres by shore and outfall had high localized concentrations of PCBs, so agency did not want to dredge, but instead required a cap (thin enough to preserve salt water habitat but thick enough to withstand high energy environment) • EPA wanted geotextile layer to stop burrowing shrimp; somehow, geogrid was installed instead (27) • Some disagreement on PCB action level between agencies; EPA convinced project team to cap greater area with clean sand (27)	A, E, 27

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Built	Performance	Comments	References
25	North Energy Island Borrow Pit Capping Pilot Study Long Beach Harbor, California (pilot CAD)	DDT, metals, PAHs, others (47)	Borrow pit created as result of construction of energy islands (47) Flat pit bottom, 52 to 66 ft. deep 0.5 mile offshore of Long Beach (47)	3 ft. minimum required (47) 4.9 ft. max. (47)	Clean silty sand dredged from entrance to Long Beach Harbor (47) 100,000 cy of contaminated sediment from the LA River estuary were deposited (37) in one segment of the pit that was already segmented by berms from a water line (47)	9.9 acres (47) Entire Pit: 220 acres approx. [c]	disposal in Aug. 2001 (47) cap construction completed in Dec. 2001 2-3 more years to study the pilot CAD cell (37, 47)	• Construction phase report expected in March • Pilot CAD cell to be closely studied (e.g., coring, benthic, bathymetry) over next 2-3 years • One of the biggest questions is the degree of bioturbation that will occur (37) • Fine silts in the pit bottom and clays consolidated very quickly, making it difficult to account for all material (47) • Monitoring plan is being developed now (47)	• The LA Contaminated Sediments Task Force is evaluating several contaminated sediment disposal options for the region, including use of CAD cells; no judgement has been made to date and will not for at least another 2-3 years (37, 47) • USACE is performing an EIS for this 1st multi-user CAD site, which will cap up to 7 million cy of contaminated sediments with clean sediment; several engineering issues being considered (e.g., separate cells vs. layering of project sediments); several other issues being considered (contaminant limits, maximum duration of exposure) (27) • One pilot study was conducted that pertained to capping; other pilot studies were conducted that address other engineering topics (47)	P, 27, 37, 47

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26	Palos Verdes Shelf San Pedro, California (pilot ISC)	DDT and PCBs	17-sq.mi. continental shelf and slope (34)	Cell LU: 15-45 cm Cell LD: <10 cm Cell SU: 15 cm	Clean sediments (two types)	135 acres (made up of three 300 x 600 m areas)	Aug. 2, 2000 to Sept. 14, 2000	Preliminary Results (Ref. H): • Disturbance of contaminated sediments was relatively localized and decreased substantially after the initial load was placed • Sediment plumes caused by capping did not pose a risk to near shore kelp beds • Spreading was less disruptive than conventional placement • There were no indications of mass sediment movement (such as mud waves or turbidity flows) as a result of capping • The pilot study went well; all indications show cap was successfully placed; monitoring continues, and indicates possible transport of contaminated sediments to cap from uncapped areas; more coring will be conducted to study this (34)	• The final report for study may be issued in March, 2002 (34) • 9/28/01 Action Memorandum (Ref. I) proposes establishing institutional controls (outreach & education, monitoring and enforcement) associated with consumption of contaminated fish • EPA continues to evaluate in-situ capping and other remedies and may issue proposed alternatives by year-end, 2002 (34)	G, H, I, 34
27	McCormick and Baxter Old Mormon Slough Stockton, California	Dioxins, PAHs	Dead-end waterway; 10 ft. deep; maintenance-dredged for barge access; tidally influenced	2 ft.	Sand	8.8 acres	Construction may begin in 2002 (35)		• ROD signed 4/99 • Capping selected because site is at the end of a dead-end slough, so cap is unlikely to wash away (35)	AA, 35
28	McCormick and Baxter Willamette River Portland, Oregon (ISC)	Heavy metals, PAHs	15 acres of near shore sediments and soils; depths to 35 ft.	3 ft.	Sand	15 acres (S) Cap may take 17 to 22 acres, depending on how thickness will vary (21)	Aiming for construction in 2004 (21)		• Long-term monitoring, OMMP, and institutional controls were also specified (A) • Cap being redesigned now (recently decided to install a piling wall around upland site to contain NAPL on site, thereby preserving treatment options in the future -waiting to see how Eagle Harbor wall performs) (21) • Habitat will be considered, particularly for juvenile salmon (21)	A, E, S, 21

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Built	Performance	Comments	References
29	Ross Island Lagoon/ Port of Portland Portland Oregon (CAD)	Metals, TBT, PAHs, PCBs (41); some COCs more prevalent in certain cells (57)	lagoon; no significant current (57); first CAD cell depth: ~80 ft.; other CAD cell depths: 0-30 ft. (57)	1 ft. (41) 1 ft. minimum for Cells 1-4; 2 to 10+ ft. for Cell 5 (61) Some discussion in late 1990s about increasing cap thickness; details not provided (57)	Fine-grained material derived from on-site sand and gravel washing and processing operations (39) Material from Ross Island rock crushing settling pond (61)	8.4 acres[(d)]	Dredging from 1992 to 1998 Cell 5 was first to be constructed	• OR DEQ accepted a Dec. 2000 study showing that contaminated sediments from Port facilities in capped disposal areas do not pose a threat to human health or the environment (40) • CAD cells are working well; model developed from data predicts no exceedances of any water quality criteria in the next 500 years (57) • A barge tipped over in 1998; the spilled material was covered with a 1-ft cap; a portion of the Cell 5 cap was breached and repaired in 1998 (57, 61)	• In five Port dredging events from 1992 to 1998, ~160,000 cy of dredged material were transported to the lagoon for permitted confined disposal; RIS&G accepted, placed and capped the in-water containment cells (39) • 4 cells accepted material from navigational dredging; 1 cell accepted material from the Port of Portland's Pencil Pitch spill (57) • Some discussion about lowering dike between two islands; current hydrology study is studying possible effects on cap integrity (57)	D, T, 39, 40, 41, 57, 61
30	Inlet Basin Soda Lake, Wyoming (case study)	PAHs, benzene, metals, NAPL	Natural playa basin, 2-12 ft. deep; recharges each year by runoff and dries later in the year (H)	1.5 ft.	Native sand	5.6 acres	Before June 15, 2000 and Aug. 31, 2000	• After 3 months, the upper 2 feet of cap contained no organic contaminants in excess of screening levels • Short-term effects from cap placement were minimal • Long-term integrity also evaluated	• The Draft Final Remedy Decision dated Oct. 29. 2001 does not propose capping, but instead proposes excavation • The WY DEQ concluded that the best alternative would be to excavate the sludge and place it in a lined corrective action management unit. Capping was not implemented. (17)	H, L, 17
Great Lakes										
31	Upper River section Sheboygan River, Wisconsin (pilot)	PCBs	9 hotspots totaling 1,200 sq. yds.	1 ft. of coarse material and upper geotextile over lower geotextile fabric	Armored stone composite	0.25 acre	1989-1990	• No monitoring data • Cap appears to be intact with significant silting-over and thus additional stabilization • Undetermined cap effectiveness • Some erosion of fine-grained material	• Composite armored cap required because of location in high-energy river environment. Gabions placed at corners for anchoring. Additional course material placed in voids and gaps. • A 1990 bench-scale armoring study by Enseco, Inc. indicated that capping had a significant effect on reducing PCB concentration measured in exposed aquatic organisms (E).	A, E, D

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Built	Performance	Comments	References
32	Areas C and D Manistique, Michigan	PCBs		2.7 ft.	Composite	17 acres	Planned, but not implemented (site remediation was dredging)	• Project not built	• Composite cap over a 17-acre site includes armoring and geotextiles	A
33	Manistique Capping Project Michigan (ISC)	PCBs	Shoal in river with depths of 10-15 ft.	40-mil (0.1 ft.)	HDPE	0.6 acre	1993	• Physical inspection of temporary cap approximately 1 year after installation showed cap to be physically intact with most anchors in place	• A 240 ft. by 100 ft. HDPE temporary cap was anchored by 38 2-ton concrete blocks placed around the perimeter of the cap • This temporary cap was installed to prevent erosion of contaminated sediments within a river hotspot with elevated surface concentrations	A, B
34	Hamilton Harbor Ontario, Canada (ISC demonstration)	PAHs, metals, nutrients	Lacustrine waterbody	1.6 ft.	Clean sand	2.5 acres	1995	• Significant reductions in the flux of site contaminants were observed after capping (D)	• Capping selected because of impracticality of dredging and upland disposal due to large sediment volumes (E)	A, B, D, E
35	Madison Metropolitan Sewerage District Lagoons Madison, Wisconsin	PCB (greater than 50 mg/kg)	2 sludge lagoons in wetlands 141-acre site	1 ft.	Geotextile and lightweight soils			• Planned in ROD	• According to the ROD (dated March 31, 1997), the final site remedy includes the segregation and in-situ containment of sludge with PCBs > 50 mg/kg. The soil will be seeded.	E
36	Oxbow Lake near Rib River Wausau, Wisconsin (ISC) ("Snow Cap" project)	Lead	Shallow, 4-acre oxbow lake at former battery reclaiming site; important breeding habitat for small fish		4-layer composite cap (geotextile and sand blanket, w/ 2nd layer of geotextile and rock "islands"); then snow		Winter, 1997, to take advantage of snow and ice	• Data from 5 locations during Mar. 1999 found current lead concentrations in the water column to be at background or non-detect levels • Benthic organism populations noted in shallow water; vegetation becoming established on the new substrate	• This new method cost significantly less than "conventional (and environmentally invasive) sediment dredging in terms of both funding and time resources" • The technique offers the advantage of providing a safe habitat for existing fish populations • The approach costs one-third the cost to remove sediments	V

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Built	Performance	Comments	References
37	Ottawa River Toledo, Ohio (ISC Demonstration)	PCBs	0.2 mile stretch; estuary with low flows; 8 ft. deep	0.33 to 0.66 ft.	AquaBlok™ (clay-mineral aggregate), with or without geotextile	2.5 acres	1999	• Monitoring results limited (E) • Ohio EPA completed a benthic community study before AquaBlok™ application and found the site to be sterile; there are plans to conduct a follow-up study in 2001, but improvements may not be seen because of ongoing contamination from a nearby Superfund site (45)	• The goal of the demonstration was to assess application methods, not necessarily provide permanent remediation (45) • The Ottawa River has a 100-year flow velocity of 4.8 ft/sec for approx. 1 hour. Flume tests of similar AquaBlok ™ compositions withstood water velocities of 6 ft/sec for 50 hours with an approximate 10% loss. (45)	E, 45
38	Triangle Pond Tommy Thompson Park Downsview, Ontario	Lead, iron, oil & grease	Man-made water body in park	1.6-9.8 ft. design 6.6-13.1 ft. actual	Clean sand and fill	2 acres	1999			C, O, U
New England/New York										
39	Stamford-New Haven-N New Haven, Connecticut (Central Long Island Sound (CLIS) area)	Metals, PAHs	Flat bottom ~65 ft. deep	1.6 ft. (A) Up to 7-10 ft. (F)	Sand		1978	• No chemical migration • 11 years of monitoring show this to be one of the most stable mounds	• Cores collected in 1990 • Contaminated sediment from Stamford Harbor was capped with slightly less contaminated material from New Haven Harbor (FF)	A, F, FF
40	Stamford-New Haven-S New Haven, Connecticut (CLIS area)	Metals, PAHs	Flat bottom ~70 ft. deep	1.6 ft. (A) Up to 13 ft. (F)	Silt		1978	• No chemical migration • 11 years of monitoring show this to be one of the most stable mounds	• Cores collected in 1990 • Contaminated sediment from Stamford Harbor was capped with slightly less contaminated material from New Haven Harbor (FF)	A, F, FF

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Built	Performance	Comments	References
41	New York Mud Dump Disposal Site (a.k.a. "New York Bight" or "Long Island Bight")	Metals in silt and clay dredged from 6 projects in NY Harbor (E)	Flat bottom 80-90 ft. deep (F)	3-4 ft. avg. 5-9 ft. max.(F)	Mud (120,300 cy) Sand (1,200,700 cy) (E)		1980	• No chemical migration	• Cores taken in 1993 (3.5 years later) showed cap integrity over relocated sediments in 80 ft. of water (A) • Simultaneous with the Mud Dump Site closure, the site and vicinity will be redesignated as the Historic Area Remediation Site (HARS) • A portion of HARS will be remediated, with approximately 1 m of capped clean dredged material (E)	A, E, W
42	New York Mud Dump Capping Project New York, New York (CAD)	Trace dioxin	Open water sediment disposal site (500,000 cy)	3.2 ft.	Clean sand		1993-1994	• Long-term monitoring being conducted • Engineering of cap construction considered a success		D
43	Historic Area Remediation Site (HARS) (former Mud Dump region)	PAHs, PCBs, DDT, dioxin, metals	HARS is 15 sq. nautical miles; water depths: 40 - 138 ft.	3.2 ft.	Relatively clean dredged sediments	9.0 square nautical miles (7638 acres)	To be constructed		Required under proposed rule in 40 CFR 228	LL, MM
44	Mill-Quinnipiac River (MQR) Connecticut (CLIS area)	Metals, PAHs	Flat bottom ~65 ft. deep	1.6 ft. (A) 6-10 ft. avg. (F) 4.9 ft. as of 8/91 (PP) 9.8 ft. as of 9/93 (RR, SS)	Silt	10.7[(e)]	1981-1982 1982-1983 1993-1994 (SS)	• Due to slow, retrograde recolonization rates, cores were collected in 1991 -showed presence of PAHs in the cap (PP) • One year later, benthic improvements were noted (QQ) • In Sept. 1993, more cap material was placed. July 1994 monitoring showed that the mound height had increased by another 1.5 m, the diameter had not changed, and recolonization rates met or exceeded the targeted rates (RR) • Small to moderate pockets of consolidation near the apex and SW flank were noted (SS)	• PAHs were not included in the protocols in 1982 when the first cap was placed. (PAHs were included in the protocol starting in 1989).	A, F, PP, QQ, RR, SS
45	Norwalk, Connecticut (CLIS area)	Metals, PAHs	Flat bottom ~65 ft. deep	1.6 ft. (A) up to 6-7 ft. (F)	Silt		1981	• No problems	• Routine monitoring	A, F

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Built	Performance	Comments	References
46	Central Long Island Sound Disposal Site (CLIS) Long Island, New York	PCBs metals, oil & grease	Multiple sediment disposal mounds	20 -41 cm (A) 0.5 - 3 ft. typical (PP, QQ, RR, SS)	Course sand and shell fragments	Varies	1979-1983 (A) Continued well into the 1990s (SS) and probably still active	• Some cores show uniform structure with low-level chemicals and others show no chemical migration • Some slumping noted (A) • As of 1996, no evidence of particle re-suspension or cap erosion; stable benthic communities over the majority of stations sampled; effects of seasonal hypoxia recognized at other stations (SS)	• Extensive coring study at multiple mounds showed cap stable at many locations • Poor recolonization in many areas • Most cap elevation changes due to consolidation, not erosion • Early 1990 coring results indicate that the cap layers continue to isolate contaminants from water column (B)	A, E, PP, QQ, RR, SS
47	Cap Site 1 Connecticut (CLIS area)	Metals, PAHs	Generally flat ~60 ft. deep	1.6 ft.	Silt		1983	• No chemical migration	• Cores collected in 1990	A, F
48	Cap Site 2 Connecticut (CLIS area)	Metals, PAHs	Generally flat ~56 ft. deep	1.6 ft. (A) 0.6-4.5 ft. (F)	Sand		1983	• Required additional cap • One of the more successful mounds	• Cores collected in 1990	A, F, FF
49	Experimental Mud Dam New York (CAD)	Metals, PAHs		3.3 ft.	Sand		1983	• No chemical migration; minor cap erosion (FF)	• Cores collected in 1990	A, FF

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Built	Performance	Comments	References
50	New Haven Harbor New Haven, Connecticut NHAV 93 (CLIS area)	Metals, PAHs	Generally flat 60 ft. deep; part of a large-scale CAD project	1.6 ft. (A) 1.6 - 3.2 ft. (TT)	Silt	50.0 acres (UDM deposit itself) and 70 - 124 acres (total mound) (estimated from Ref. TT)	1993-1994	• No chemical migration (A) • July 1994 monitoring noted no major topographic changes and maintenance of minimum required thickness of 0.5 m (average thickness was 0.75 m along margins of the UDM deposit, and 1.25 m at center (RR) • Target recolonization rates were met or exceeded in most areas, except for three; Sept. 1994 tests demonstrated that cap supplementation was not required (RR) • Aug. 1995-Sept. 1995 monitoring showed moderate amounts of consolidation (0.25 m over most of cap, and 0.5 m near center); 1996 monitoring noted 0.25 to 0.75 m of consolidation over majority of mound with little change in size or shape, and that benthic community continued to recover (SS)	• From 1984 to 1992, contaminated sediments were disposed in 7 separate mounds that were located to form a ring (UU) • In 1993, sediments from New Haven Harbor and five private marinas were placed in the middle of the ring and later capped. Significant consolidation was noted before capping took place(TT) • Capping was completed by Mar. 1994 (RR)	A, FF, RR, SS, TT, UU
51	CLIS 94 Mound CLIS Area			1.6 to 3.2 ft.	Dredged material	43 acres[f]	Jan. 1995 to May 1995 (UU)	• Sept. 1995 monitoring showed good benthic recovery despite added stress of seasonal hypoxia and recent impact of disposal (UU) • July 1996 monitoring showed continued benthic recovery, higher dissolved oxygen and several pockets of consolidation at apex (0.25 to 0.5 m) (SS)	• This mound forms the beginning of the second placement ring which will eventually become a CAD • This mound completely envelopes the CS-90-1 mound (UU)	SS, UU
52	CLIS 95 Mound CLIS Area		Small, capped, dredged disposal mound	5.2 ft. (estimated from volume and area) (SS)	Dredged material	7.8 acres[g]	Sept. 1, 1995 (SS)	• Rapid recolonization of sediments observed (SS)	• Slightly irregular shape, due to bottom slope and distribution of capping material (SS) • The CDM:UDM ratio is 3.1:1.0 (SS)	SS
53	Port Newark/Elizabeth Project New York	Metals, PAHs, low levels of dioxin (FF)		5.3 ft. 1 m design(FF)	Sand	198[b]	1993	• No chemical migration	• Extensive coring study	A, FF

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Built	Performance	Comments	References
54	52 Smaller Projects New England	Metals, PAHs		1.6 ft.	Silt		1980-1995	• No chemical migration	• Routine monitoring	A
55	New London Disposal Site, Thames River, Connecticut		49 ft. deep	Irregular, 10 to 70 cm	Clean sediment		1988-1989			C, FF
56	S-90-1 Harbor Village/Branford River (CLIS area)		Generally flat 60 ft. deep	Incomplete coverage; several distinct cap mounds 0.6 to 2 ft. thick			1989-1990			FF
57	Massachusetts Bay Disposal Site Massachusetts (Demonstration)		90 miles deep; 22 naut. mi ENE from Boston		Clean sediment					C
58	Portland Disposal Site Yarmouth, Maine	Metals, PAHs	177 ft. and deeper		Fine-grained dredged sediment & sandy material		Oct. 1991 to June 1992	• Sediment chemistry data showed that the cap effectively isolates contaminants		VV
59	Portland Disposal Site Yarmouth, Maine (Demonstration Project)	Metals, PAHs	Deep water ocean disposal site; 210 ft. deep	1.6 ft. 0.7 ft. (WW)				• Project showed that dredged material may be effectively placed, capped, and monitored at deep water disposal sites (WW)	• "A tightly controlled, closely monitored deep-water demonstration capping project in which clean sediment was capped with 20 cm of clean sediment" (WW)	II, WW
60	General Motors Superfund Site St. Lawrence River Massena, New York	PCBs	11-acre near shore site; depth of river at cap no deeper than 4 ft. (XX)	1.5 ft.	Sand, gravel and armor stone	1.7 acre	1995	• In 1999, armored cap appeared intact with minimal disturbance; no routine maintenance required; however, additional armor material added in 1998 to restore minor nearshore areas (D) • The cap is working very well, based on yearly inspections. In the first year, minor repairs were required (more fill rock) (XX)	• Capping used where repeated dredging failed • As of 1996, cap has maintained its integrity as a whole. Direct comparison of pre-remediation fish data with post-remediation data is complicated by uncertainties about collection locations for the pre-remediation fish. There are data anomalies. (Z) • Water velocities in the River range from 2.75 to 4.42 ft/sec (D) • Cap consisted of sand, activated carbon and gravel (24)	B, E, Z, XX, 24

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Built	Performance	Comments	References
61	Reynolds Metals Co. Massena, New York	PCBs, PAHs, lead, other organics, other metals (60)					Nov. 2001 (59)		• Message left with EPA Region 2 • ROD abstract states that untreated sediment and treated residuals will be disposed onsite in the Black Mud Pond and that the Pond will be capped	59, 60
62	ALCOA Grasse River Massena, New York (Pilot study)	PCBs	Backwater to St. Lawrence River; approx. 20 ft. deep; study covered 750 ft. section (26)		Test materials: • 1:1 sand/topsoil mixture • granulated bentonite (clay) material • AquaBlok ™ (these 3 test materials were used alone or in combination) (26)	Approx. 7.5 to 8 acres (25)	July 9, 2001 to Oct. 19, 2001	• Extensive monitoring conducted prior to, throughout, and after the capping pilot study work(26) • The study concluded that a cap to cover the PCB-containing sediments can be successfully constructed in the Lower Grasse River (26) • Optimal results achieved with a 1:1 sand/topsoil cap applied via a clamshell attached to a barge-mounted crane (26) • Little apparent short-term impacts noted during pilot project; negligible water quality impacts; monitoring will continue in 2002 (26) • Capping will be carried into the Feasibility Study, both singly, and in combination with other remedies (25)	• Capping is one of the cleanup alternatives being evaluated for remediation of contaminated sediments in the Lower Grasse River • The study was conducted to better understand how different capping materials could be installed on the river bottom using various placement techniques (26) • Capping was performed in two phases: initial "Test Cell " to test potential materials and placement techniques; real-time results from the Test Cells were evaluated and select capping techniques and materials were then used in larger "Pilot Cells" (26) • Steep side slopes were a particular concern (25)	15, 25, 26

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Built	Performance	Comments	References
63	Marathon Battery Superfund Site East Foundry Cove Marsh Cold Spring, New York (cap and habitat restoration)	Cadmium, nickel, cobalt	Shallow estuarine	1-2 ft. cover soil (11)	BentoMat (1 in. Bentonite clay between 2 layers of geotextiles, material expands when wet); 1 -2 ft. of clean fill on top (11)	12 acres (11)	April 1995 (AA)	• Increases in sediment Cd concentrations probably due to cyclic flooding of marsh during high tide (D) • Several problems experienced (e.g., replanting difficulties due to ice (in first year, bad ice flow destroyed cattails), geese (which eat the young shoots), tidal velocities that prevent seed settling) (11) • Snow fences and other measures implemented (11)	• Highest contamination levels in East Foundry Cove Marsh near the plant's former outfall: 171,000, 156,000 and 6,700 mg/kg for Cd, Ni, and Co, respectively (12) • Mean Cd concentration: 27,799 ppm (D) • Sediments were excavated (average post-excavation concentration was approx. 25 ppm for Cd, with no sample exceeding 100 ppm cleanup goal) • The area was subsequently capped to isolate residual Cd from hydrologic and biologic processes, and to restore habitat (11, 13)	D, AA, 11, 12, 13
64	Rhode Island Sound		108-115 ft. deep; <0.5 ft/s bottom currents	Irregular, with some bald spots <17.4 ft.	Compacted silts and sand					C
65	Boston Harbor Navigation Improvement Project Massachusetts (CAD)	Multiple	Mystic River: 40 ft. MLLW Chelsea Creek: 38 ft. MLLW 8+ ft. tide (8)	3 ft. for each CAD cell (8)	Clean sand from Cape Cod Canal	2.4 acres [(h)]	1997: 1 CAD Cell at Conley Terminal 1998-2000: 7 CAD cells in Mystic River, including one "Super Cell" 2000-2001: 1 CAD cell in Chelsea Creek (8)	• Key lesson learned: allow the contaminated materials to consolidate for several months or more before capping (CC) • Longest consolidation period was 200 days (8) • Other lessons learned: how far cells could be filled before causing "slop out" (8) • Corps originally planned to have 60 shallow cells, no deeper than 20 ft. each, but modified plan to have fewer, deeper cells (some as deep as 80 feet) (8)	• 40 to 60 ft. deep pits dug to contain contaminated sediments • The Conley Terminal CAD cell was a test case and Boston's first capping project • Because benthic community returned without cap, that CAD cell was not capped • Lessons learned from that site were applied to subsequent CAD cells (8) • Chelsea Creek CAD cell still has 50,000 cy capacity to be filled, so will probably remain uncapped for 5 years • A vessel passage study was conducted to ensure that the deepest and most powerful ships in channel would not pull silt out- CAD cells performed quite well in tests (8)	J, T, CC, HH, JJ, 8

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Built	Performance	Comments	References
66	Upper Acushnet River Estuary/ New Bedford Harbor Massachusetts (pilot CAD)	PCBs, heavy metals	Estuary; pilot test site was small cove north of Coggeshall St. Bridge; depth ranged from 0.0 to 0.5 ft. (MLW)	2 ft.	Clean sediment produced during pilot study	CAD cell measured 180 ft. by 140 ft. (25,200 sq. ft., 0.6 acre)	Jan. 1989 to Feb. 1989	• Analysis of six sediment cores taken on June 22, 1989, revealed elevated levels of PCBs in the surface layers of sediment, indicating that capping efforts were unsuccessful. The results pointed out the need for a high degree of control on the positioning and movement of the discharge point within the CAD cell. The position of the diffuser within 2 feet of the contaminated sediment layer may have resulted in a mixing of sediments. A deeper CAD cell would allow the diffuser to be separated from the contaminated sediment layer while still remaining within the confines of the cell.	• The pilot study evaluated three types of hydraulic pipeline dredges, and two types of disposal methods (CADs and CDFs) • The bottom elevation of the CAD cell was approx. -6 ft. MLW; Within the 180 ft. by 140 ft. cross section, a 50 ft. by 50 ft. section had bottom elevation of -8 ft. MLW • Suspended sediment and contaminant levels were elevated in the vicinity of the CAD cell compared to background conditions and other phases of the study (a silt curtain was not in use during monitoring) • A statistically significant increase in contaminant levels was not detected at the Coggeshall Street Bridge	7
67	Providence River and Harbor Maintenance Dredging (CAD)	Various (6)	Channel depth 35 to 43 ft. now (6)	Target thickness 1 ft. minimum; 3 ft. desired (6)	Suitable sediments from lower in the channel (6)	308 acres (6)	Possibly Nov. 2002 or spring or summer 2003 (6)		• Five CAD cells currently designed for the Upper River to contain 1.2 million cy of dredged material (subject to change) • EPA is "on-board" with the project • EPA comments of 10/01 pertaining to dilution and mixing zone water quality requirements (Ref. K) have been addressed; final Water Quality Certification is pending	K, 6
68	Pine Street Barge Canal Burlington, Vermont (ISC)	PAHs, metals, VOCs	Northern end (turning basin) depth is 8-10 ft.; Southern end depth is 2-3 ft.; possibly 2 ft. higher in spring (5)	Possible thickness is 1.5 to 2 ft. if sand is used; if geotextile is also used, thickness may be less (5)	Sand/silt, with or without geotextile (5)	5-6 acres of affected canal sediments and 2-3 acres of wetlands	To be constructed ; may be complete in 2003 (5)	• ROD specifies a cap (5)	• Original remedial action required dredging; local opposition, then public consensus, led to development of in-situ capping remedy	E, T, 5

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Built	Performance	Comments	References
69	Housatonic River, Upper 1/2 Mile General Electric Site Pittsfield, Massachusetts	PCBs	Water depth typically 3-4 ft. (can range from 2-10 ft.) (YY); average flow 105 cfs (AA)	1 ft. silty sand; 1 ft. armor stone (62)	Multi-layer river cap: geotextile, silty sand with >0.5 % TOC, geotextile, GeoGrid, armor stone (62)	possibly 2-3 acres, based on drawings in Work Plan (62)			• Purpose of cap/armor is to provide a chemical and physical barrier between the residual PCBs (after removal of contaminated sediment) and the overlying water (62) • A 12-inch thick silty sand layer with a 0.5% TOC concentration is proposed for the majority of the area; in certain areas, a 6-inch thick silty sand layer will be installed where 1.5 ft. sediment removals is proposed; an 18-inch thick silty sand layer will be used in one area where deeper excavation is proposed (62)	Y, AA, YY
70	Messer Street Gas Plant Winnipesaukee River Laconia, NH	PAHs	Depth at underground phone cables 10-15 ft.	1 ft.	Course gravel, similar to on-site conditions	<0.1 acre	2000-2001	• Project went well • Too early to identify any issues • Monitoring will be conducted where free product was removed and sediment excavated	• Overall design relied more on excavation than capping ("stabilization") • Stabilization was used primarily in one area where buried telephone cables cross the river • Stabilization specifically not used if free product was present, area was subject to scour, or depth was less than 10 ft. • Other isolated portions of the 18 separate remediation areas may have used stabilization	4

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Built	Performance	Comments	References
71	Rahway River Linden, New Jersey	DDT, metals	RCRA Corrective Action at industrial facility		Nonwoven geotextile, native sediment, sand filter material, second geotextile layer, rip rap armor	0.5 acre		• Cap construction is complete and has received final closure approval	• Message left with the NJDEP	E
Other Domestic Projects										
72	Lower Mobile Bay Alabama (ISC) pilot		Open ocean thin layer disposal	1 ft. maximum	Silt maintenance dredged material	<10 acres	1988	• Pre-, during, and post-project monitoring was conducted by the Mobile District (of US ACE), WES, and EPA • Motile and non-motile organism impacts and recolonization and water quality were monitored • Minimal impacts resulted, and organism levels were at pre-project levels in 6 months • Project considered a success (16)	• Energy sources: long wind fetch across Mobile Bay and surface wave energies from boats and natural conditions (16)	W, 16
73	Anacostia Watershed Prince George's County, Maryland (pilot)	PCBs, PAHs, pesticides, metals	15-20 ft. depths; near shore site with heavy propeller wash			10,000 sq.ft.	To be constructed (design should start this summer)	• Full commitment made to conduct pilot study	• Because there are a number of contaminated sediment sites on the Anacostia River, the entire watershed will be addressed in its entirety, with stakeholder input • Final remedy anticipated to be reactive cap	14

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Built	Performance	Comments	References
74	Koppers Superfund Site Charleston, South Carolina (ISC)	PAHs, pentachoro- phenol, trace dioxin, lead, arsenic	Ashley River; intertidal system; 1,500 ft. reach; cap mostly in intertidal zone; under 6 ft. of water at high tide (18)	1.5 ft. minimum	Geotextile and minimum of 18 in. sand (18)	3 acres (18)	Dec. 2001 (18)		• Originally, only sediments in the Barge Canal were to be capped, and enhanced natural sedimentation was to be used in the Ashley River • Due to public concern with sheet piles surrounding property access, and agency's desire to avoid delays, EPA decided to cap the Ashley River • Approx. 2 ft. of sediment has already naturally deposited on the Barge Canal, but EPA will continue to evaluate the remedy for the Barge Canal (18) • Sediments in the Barge Canal are "marginally toxic" (AA)	AA, 18
75	Calhoun Park/Aquarium Charleston, South Carolina	PAHs (former coal gas manufactu-ring plant)	Cooper River intertidal area; portion above water line at low tide; a portion continually submerged (19)	3 ft.	Clean sand	0.5 - 0.75 acre, estimated (19)	1996	• Sand cap an interim measure, not a formal remedy • Some scouring and mounding noted • Very dynamic environment (19)	• An aquarium was proposed to be built on the site. To avoid resuspension of PAHs during construction of 300 pilings, 3 ft. of clean sand was first laid (without geotextile) (18) • Ecological risk assessment warrants further evaluation of formal remedy, although aquarium and National Park Service boat dock present physical constraints (19)	18, 19

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Built	Performance	Comments	References
76	Ward Cove Ketchikan, Alaska (thin-layer capping)	Ammonia, sulfide, and 4-methylphenol (AA) (generated in place from existing contami-nation)	Deep estuary, 1 mi. long & 0.5 mi wide; water depth at proposed capping areas: -10 to -110 ft. MLLW (AA) Very soft organic sediments; 80-acre AOC (X)	0.5 - 1 ft. 0.5 -0.75 ft. (X)	Clean sand from upland borrow source (10)	27 acres (10)	Feb. 2001	• All sediment targeted for capping was covered by a thin-layer cap (10) • The project went very smoothly; the AOC will be sampled every third July or until remedial objectives are achieved (1) • Contractor had to verify that cap was properly placed (10) • First monitoring event will take place in 2004 (chemical monitoring and bioassays will be conducted) (10) • Lessons learned: (1) possible to place uniform cap on soft sediments with clamshell, (2) use a trial and error approach, (3) success when a close owner/contractor/regulator working relationship is in place to allow field modifications to meet clean-up objectives (X)	• Originally, 21 acres were going to be covered by a thin cap and 5 ft. of mounding would be used on another 6 acres. The mound capping was not required since thin-layer caps could be supported by the sediment. • Natural recovery was used where capping was infeasible, on 53 acres of the site (10) • The thin layer cap provides a clean substrate for recolonization of the benthic community (10)	X, AA, 1, 10
77	Eagle River Flats Fort Richardson Army Base Anchorage, Alaska (pilot and follow-up study)	White phosphorus	Estuarine salt marsh next to former army firing range	3 to 4 inch layer (42)	Hydrated AquaBlok™	1.2 acre (1994 study)	1993 (pilot) 1994 (definitive study)	• The AquaBlok™ immediately and significantly reduced the mortality of the duck test population (42) • After one year, the treated area became revegetated and supported benthic life (42) • After four years of exposure to extreme temperature and tidal influences, the treated area remains capped (42) • Data collected to date indicates that AquaBlok™ shows promise for reducing waterfowl mortality from white phosphorous poisoning (43)	• High waterfowl mortality was observed in early 1980s and traced to ingestion of white phosphorus-impacted sediments • 1993 pilot study indicated that the system could reduce mortality of foraging waterfowl (43) • Definitive study conducted in 1994 to evaluate the longevity of the system and measure its effects on waterfowl foraging behavior and mortality (43)	42, 43

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Built	Performance	Comments	References
78	Eagle River Flats Fort Richardson Army Base Anchorage, Alaska (full-scale)	White phosphorus	Estuarine salt marsh next to former army firing range						• Preferred remediation method in Oct. 1998 ROD is to temporarily drain ponds to allow the pond sediments to dry out and allow white phosphorous to sublimate and oxidize over a five year period, and then cap and fill area with AquaBlok™ where white phosphorous exposure remains a concern (44) • AquaBlok™ would only be applied to small, deep portions of pond bottoms and would not significantly change overall pond depths or feeding habitat (44)	44
79	Nome, Alaska (CAD)		Harbor depth 20 ft.	4 ft.		1 acre			• Small project similar to One Tree Island, in which contaminated surface layer was dug up and deposited in CAD cell. • Approx. 35,000 cy of material placed in CAD cell	21
80	ALCOA (Point Comfort)/Lavaca Bay Site Point Comfort, Texas (thin layer capping)	Mercury	Tidal-estuarine; always underwater; water depth approx. 6-8 ft.	0.5 ft.	Hoping to find a new clay material; possible use of dredge spoils from federally maintained channel	50 acres estimated	ROD signed in Dec. 2001; construction may start in Dec. 2002		• Remedy will include dredging, capping, and natural recovery • Thin layer cap will be used to accelerate natural sedimentation • Final design not complete • Modeling of Category 5 hurricane indicated wet deposition, not exposure of deeper sediment	20
81	Homestead Air Force Base Outfall Canal (OU-11) Florida	PAHs, metals (2)	Canal approx. 40-50 ft. wide, 1 mile long and 10 ft. deep (2)	Possibly 2 ft. (2)	Possible: concrete-injected fabric, under geotextile mat, under clean sediment for plant growth (2)		In the Proposed Plan stage of Superfund (2)	• The capping remedy has been approved by the Air Force, EPA, the State and Durham County (3)	• Extensive storm water conveyance system of canals and swales transports the contaminants to the Canal • Canal discharges storm water to Biscayne National Park, hence the urgency to address the sediments which appear to have damaged flora and fauna adjacent to the mouth of Outfall Canal (2)	2, 3
International Projects										

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Built	Performance	Comments	References
82	Rotterdam Harbor Netherlands (CAD)	Oils	Water depth 16 - 39 ft. (A)	2-3 ft.	Silt/Clay sediments	Est. minimum of 16.3 acres[(i)]	1984	• No available monitoring data	• Groundwater pollution was a potential concern so site was lined with clay prior to sediment disposal and capping	A, F, FF
83	Amsterdam Netherlands (CAD)		Harbor basins; multiple CADs							KK
84	Ijmuiden (Averijhaven) Netherlands (CAD)		Tidal waters at entrance to the North Sea; 1 CAD							KK
85	Ijmuiden (Amerikahaven) Netherlands (CAD)		Non-tidal waters in main port area; 1 CAD							KK
86	Julianakanaal Netherlands (CAD)		Shipping channel						• Deep pits in this channel were used for disposal of contaminated sediments from the River Maas	KK
87	Eitrheim Bay Norway	Metals	Water depth up to 10 m		Geotextile and gabions	100,000 m^2				B
88	Kihama Inner Lake Japan (ISC)	Nutrients	3 sites	5 and 20 cm	Fine sand	3,700 m^2				B, C
89	Akanoi Bay Japan	Nutrients	3.9 ft. deep; 2 sites	20 cm	Fine sand	20,000 m^2				B, C
90	Hiroshima Bay Japan (ISC)		Water depth 70 ft.	5.3 ft.	Sand with shell		1983	• No available data		A
91	Hiroshima Bay-Phase 1 Japan			50 cm	Sand	19,200 m^2	1979			B
92	Hiroshima Bay-Phase 2 Japan			30 cm	Sand	44,160 m^3	1980			B
93	Lake Biwa Japan			20 cm	Sand	22,000 m^2				B
94	Matsushima Bay Japan		Included dredging	30 cm	Sand	675 m^2				B

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Built	Performance	Comments	References
95	Minami-ko Japan			20 cm	Sand					C
96	Uranouchi Bay Japan		20-60 ft. deep	15-20 cm	Sand	17,400 m^2				B
97	Suonada Bay Japan		3-16 ft. deep	30-50 cm	Sand	15,900 m^2	1986-1987			B
98	Mikawa Bay Japan			40-100 cm	Sand	14,100 m^2				B
99	Tsuda Bay Japan		33-49 ft. deep	50 cm	Sand	418,000 m^2	1991-1993			B
100	Gokasho Bay Japan			20 cm	Sand	106,900 m^2				B
101	Uwajima Bay Japan			20 cm	Sand	46,800 m^2				B
102	Minimata Site Japan	Mercury		2.8 m	Geotextile sheets, two types of sand					B
103	Belgium (CAD)									T

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Built	Performance	Comments	References
104	East Sha Chau Contaminated Mud Pits Hong Kong (CAD)	Varied domestic and industrial pollutants, particularly metallic radicals (copper and chromium)		3 m minimum	Pits I-III: Initial placement: ~1m sand, then ~2m clean capping mud One year later after pit infill settling: another 1-2m clean mud to bring cap back to level of surrounding seabed (55) Pit IV: 6m - 8m	Pits I-III: 570 acres[j] Pit IV: 500 acres[j]	Pits I-III: Dec. 1992 to Dec. 1997 Pit IV: beginning in Dec. 1997	• Independent reviews of results indicate absence of adverse and/or cumulative impacts, including risks to public health and ecology, and conclude that the disposal program has effectively isolated contaminants from the marine environment (55) • The Environmental Impact Assessment study for CMP- IV determined that even though the pit would have larger surface area than previous CMPs, unacceptable environmental impacts would be unlikely as long as the maximum backfill level is limited to -14m PD. While a cap of 3m would be resistant to erosion under extreme storm events, there is space above the 3m cap for placement of about 5 m of additional clean material giving a final cap thickness of 6-8m (55) • Usefulness of sand cap layer as part of CMP-IV was re-assessed and determined to be unnecessary because the mud cap layers will be placed by hydraulic methods and because costs don't appear to be warranted - earlier caps always a revealed a distinct boundary between clean and contaminated mud (55)	• Pits designed to maximize capacity while minimizing affected seabed area (55) • Dec. 1992 to Dec. 1997: three pits used [CMP I, CMP IIa-d, and CMP IIIa-d] - these pits were dredged to base of the soft marine deposits, normally about 15 m below seabed (55) • Design process evaluated effects of storm-induced shear stress during a seasonal typhoon for uncapped pits and completed cap; possibility of remobilization and loss of contaminated sediment was very low if filled depth was limited to 9m below sea level; geophysical surveys showed maximum natural scour to be ~1m, so 3m cap thickness used (55) • Design cap also precludes burrowing organisms and anchors of shallow draft ships from breaching the cap (55) • After Dec. 1997: CMP-IV used; these were exhausted marine sand borrow pits with estimated volume of 30 Mm^3 expected (55) • Capacity in the 4th pit will be exhausted in late 2007 (56) or 2003 at least (55) • New CAD sites are being considered (BB, 56) • 22 Mm^3 disposed of from Dec. 1992 to approx. Jan. 2001 (BB); 40 Mm^3 expected by 2003 (55)	T, BB, 55, 56
105	Lake Schwelvollert Trebnitz, Germany (ISC)	Phenols, ammonium, PAHs	Former open mining pit; 89 ft. deep max.; 9 hectares							DD, EE
106	Sweden (ISC)									T

	Sediment Project	Chemicals of Concern	Site Conditions	Design Thickness	Cap Material	Cap Area	Date Built	Performance	Comments	References
107	Lake Turingen Sweden (pilot ISC)	Mercury	197 acre lake, with maximum depth of 10 m	3 cm gel (Vattenresurs AB process)	Proprietary gel material ("artificial sediment")					52
108	Lake Turingen Sweden (full scale)	Mercury (from paper mill releases from 1946-1966)	197 acre lake, with maximum depth of 10 m (52)	Phase 1: cap - not specified Phase 2 cap: 5 cm (~2 in.) (52)	Phase 1 cap: geotextile and "suitable clean technological material" (53) Phase 2 cap: proprietary gel material ("artificial sediment") (52)	Phase 1 cap: not specified Phase 2 cap: 198 acres (52)	Phase 2 cap: to be completed in late autumn 2002 (52)		• Phase 1: dredge sediments from the final reaches of River Turingen channel and section of Lake Turingen just outside of mouth of river; "clean" several shallow areas of the lake near river mouth; spoils to be redeposited underwater in the southern part of the lake; cap non-dredged areas of the lake near the river mouth (53) • Phase 2: cap the "remaining accumulation in the lake bottoms with artificial gel" (53) • Vattenresurs AB in Sweden patented the Phase 2 capping method (52) • Raceway testing shows Phase 2 cap can manage current of 0.3 m/s (52)	52, 53
109	Sørfjorden Site Norway	Zinc, lead (54) (Concentra-tions of metals in sediment exceeded 10% zinc and 0.9% lead) (54)	Small bay near zinc factory; water depth < 33 ft.	30-60 cm (B) 30 cm sand over permeable membrane (54)	Nonwoven geomembrane and woven polyester geotextile and sand (B)	17.3 acres (54)		• Capping was selected because of fears of gross contamination during dredging and lack of safe areas to deposit spoils; the industrial waste in bay is a very significant source of pollution; the contaminated material at the shoreline is exposed to tides and waves and is continually eroded and resuspended; during stormy weather the entire bay has been colored red (54)	• The cap will be used in combination with a piled wall near shore (54) • The sandy layer on top of the membrane is meant to protect the membrane, to adsorb some of the contaminants that are transported through the membrane, and to arrange for recolonization of organisms; the membrane will prevent bioturbation into the contaminated sediments and erosion of the sediments during stormy weather (54)	B, 54

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C. Abbreviations:

AOC	Area of Concern
CAD	Confined Aquatic Disposal
CB/NT SS	Commencement Bay Nearshore/Tideflats Superfund Site
Cd	Cadmium
CDF	Confined Disposal Facility
CDM	Capping Dredged Material
cfs	Cubic Feet Per Second

CLIS	Central Long Island Sound
CMP	Contaminated Mud Pit
COC	Chemical of Concern
CSO	Combined Sewer Overflow
cy	Cubic Yards
DDT	Dichloro-diphenol-trichloroethane
EIS	Environmental Impact Statement
EPA	United States Environmental Protection Agency
HDPE	High Density Polyethylene
ISC	In-Situ Capping
MLW	Mean Low Water
MLLW	Mean Lower Low Water
NAPL	Non-Aqueous-Phase Liquid
NPL	National Priorities List
NUAD	Not Suitable for Unconfined Aquatic Disposal
PAH	Polycyclic Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
PCDF	Polychlorinated Dibenzofuran
RCRA	Resource Conservation and Recovery Act
ROD	Record of Decision
TBT	Tributyl Tin
TOC	Total Organic Carbon
UDM	Unacceptably Contaminated Dredged Material
USACE	United States Army Corps of Engineers
VOC	Volatile Organic Compound
WES	Waterways Experiment Station (USACE)

D. Footnotes:

(a) Estimated by dividing the 0.6 m thickness into the 3100 m3 volume (Ref. E). According to J. Malek (Ref. 21), the initial cap area was approximately 0.7 acres. Because too much material was placed in too small a hole, too quickly, there was "slopping out", so the actual cap feathered out to an area of approx. 1.3 acres.

(b) Estimated from diagram provided at http://www.wes.army.mil/el/dots/doer/pdf/trdoer1.pdf (Ref. FF). B. Ross (EPA Region 9) believes that the calculated area could be correct for the LA project.

(c) Estimated from diagram provided at http://www.wes.army.mil/el/dots/pdfs/drv1n2_3.pdf (Ref. P). Approx. 0.25 by 1.4 miles

(d) Estimated from diagram provided at http://www.epa.gov/tio/tsp/download/palermo-jointsession.pdf (Ref. T)

(e) Estimated by dividing the 1.5 m thickness (Ref. PP) into the volume of capping sediments, 65,000 cu m (Ref. RR)

(f) Estimated based on mound diameter of 470 meters (Ref. UU)

(g) Estimated based on mound diameter of 200 meters (Ref. SS)

(h) Estimated based on diagram provided (Ref. 9) for the Mystic River CAD cells

(i) Estimated from one (out of three) pit dimensions of 550 by 120 meters (Ref. EE)

(j) Estimated based on diagram provided (Ref. 55) for the East Sha Chau mud pits